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The effect of organic fertilizer, biochar, and hormones on bulb splitting in the cultivation of true seed shallot

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Abstract. The study aimed to analyze the effect of organic fertilizer, biochar and hormone to the bulb splitting in cultivation of true shallot seed. The research was conducted in Grobogan Regency, in March-June 2019. The applied experimental design was Split-Split Plot with three replications. The main plot treated with organic fertilizer (P) consisted of P1=5 t/ha, P2=10 t/ha, and P3=20 t/ha, the subsidiary plot treated Biochar (B) marked B1=without Biochar and B2=Biochar 12.5 t/ha, and the sub-subsidiary plot was treated with Hormone (H); H1=without hormone, H2=with hormone; altogether were 12 treatment combinations and 36 experimental plots. Parameters observed were plant height, number of leaves, number of plants/clump, number of bulbs/clump, number of bulbs splitting, bulbs diameter, and dry weight of bulb/clump. Data were analyzed statistically using ANOVA, and if there was a significant difference between treatments, it was tested with the Duncan Multiple Range Test at a 5% level. The results showed that the provision of biochar as many as 12.5 tons/ha positively affected the growth components and the yield components of true shallot seed (number of plants/clump, number of bulbs/clump, number of bulbs splitting, bulbs diameter, and dry weight of bulb/clump).

1. Introduction

Seed is an important component which greatly affects the increase in shallot production [1]. One of the potential alternative technologies to be developed in an effort to overcome the constraints of shallot seedlings in Indonesia is the use of botanical seeds (true seed of shallot / TSS) [2]. The use of TSS seeds has many advantages, including being more efficient, which only requires 1-5 kg/ha depending on the spacing used and the number of seeds per planting hole [3], it does not require a dormancy period thus when the new seeds are harvested they can be planted immediately, can be stored for a long period of 1-2 years, transportation becomes easier and cheaper, the production of consumption bulbs and seeds can be separated resulting the supply of shallots can be maintained [2].

Although it has many advantages, the use of TSS seeds also has several constraints, including the commonly produced bulbs are single bulbs, even by farmers in Central Java TSS is called tillerless shallots. Research result Marzuki et al [4] showed that the average yield of TSS tillers for Bima was 2.51 tillers, Trisula was 2.1 tillers and Tuk Tuk reached 1.49 tillers. Efforts to increase the number of bulbs splitting or the number of tillers in True Shallot Seed cultivation can be done by increasing the soil weakness and improving the physiological quality of shallot seeds.

Soil weakness can be increased by the use of biochar and organic fertilizers. Biochar is a soil repairer that can increase soil fertility by increasing nitrogen nutrients, maintaining soil chemical properties such as pH, CEC, and C-Organic of soil [5,6], improve soil quality and increase the productivity of shallot plants [7,8], improve aeration, increase aggregate stability, and increase soil permeability [9], can remove pollutants and stimulate a diversity of beneficial microbes in the soil [5,10-12]. In addition, biochar combined with organic fertilizers can increase the growth and yield of shallots [13].

The physiological quality of TSS can be increased by the use of hormones or growth regulators (ZPT), both natural and artificial [14]. The combination treatments among organic fertilizers, biochar and hormones are expected to be able to increase soil weakness and improve the physiological quality of TSS, thus it can increase the number of bulbs splitting in True Shallot Seed. The purpose of this study was to determine the effect of organic fertilizers, biochar and hormone on the number of bulbs splitting in true shallot seed.

2. Materials and methods

The research was conducted in March - June 2019 in Padang Village, Tanggungharjo District, Grobogan Regency, Central Java Province, Indonesia. The TSS seeds used were Bima variety, and the cultivation system used was direct seed planting (Table 1) with 3-4 seeds / planting hole and the spacing used was 10x10 cm. The research applied experimental design of Split Plot with three replications. The main plot treated with organic fertilizer (P) consisted of P1=5 t/ha, P2=10 t/ha, and P3=20 t/ha, the subsidiary plot treated with Biochar (B) marked B1=without Biochar and B2=Biochar 12.5 t/ha, and the sub-subsidiary plot was treated with Hormone (H); H1=without hormone, H2=with hormone; altogether were 12 treatment combinations and 36 experimental plots. Parameters observed were plant height, number of leaves, number of plants/clump, number of bulbs/clump, number of bulbs splitting, bulbs diameter, and dry weight of bulb/clump. Data were analyzed statistically using ANOVA, and if there was a significant difference between treatments, it was tested with the Duncan Multiple Range Test at a 5% level. The hormone used was liquid organic fertilizer (POC) which contained several kinds of hormones, namely auxin, cytokinin, kinetin, zeatin, and gibberellic acid (GA3, GA5, GA7) which were applied 3 times on 20, 30 and 40 DAP (days after planting) as much as 2 ml per liter water by spraying. The fertilization given included basic fertilization: NPK 15:15:15 533 kg / ha, SP36 111 kg / ha, and KCl 66 kg / ha, the first supplementary fertilization on 15 DAP in the form of NPK Mutiara 200 kg / ha, ZA 100 kg / ha and KN03 white 50 kg / ha given by sowing, and supplementary fertilization on 30 DAP in the form of NPK Mutiara 200 kg / ha, ZA 100 kg / ha and KN03 red 150 kg / ha.

3. Results and discussion

3.1. Components of growth

The growth component used as an indicator of the influence of the treatment given includes plant height, number of leaves, and number of tillers. The results of the DMRT test analysis with a 5% confidence level on plant height are presented in Table 1. Based on the results of further DMRT test analysis in Table 1, plant height on 45 DAP (days after planting) shows that the treatment of organic fertilizer 20 tons / ha, with the addition of 12.5 tons / ha of Biochar, and without hormones has a significant effect on providing the best plant height reaching 13.87 cm, while on 60 and 75 DAP it is not significantly different. On 60 and 75 DAP, it was not significantly different because the dose given still needed to be increased. This is in accordance with the research results Pratama (2014) showed that the provision of biochar 30 t / ha has a very significant effect on plant height on 15 DAP, 30 DAP, 45 DAP, the number of tillers per clump on 30 DAP, and 45 DAP, the number of bulbs per hill, fresh weight per hill, dry weight per hill and potential yield of shallots from bulbs. Furthermore, the application of compost, with 10% biochar and Trichoderma sp added, can have a significant effect on plant height to increase the yield of local shallots from Palu [16].

Table 1. Plant height and number of leaves of true shallot seed (TSS)

Parameters	Fertilizer	Without Biochar (B1)		12.5 tons/ha Biochar (B2)	
		H1	H2	H1	H2
Plant Height on 45 DAP (cm)	P1	11.07 ab X	11.53 ab X	11.47 ab X	11.53 ab X
	P2	12.07 a X	10.87 b Y	10.87 b Y	12.00 a X
	P3	12.00 a X	10.53 b Y	13.87 a X	12.33 a X
Plant Height on 60 DAP (cm)	P1	29.93 a X	26.60 a X	24.00 a X	22.80 a X
	P2	30.47 a X	26.80 a X	26.40 a X	26.53 a X
	P3	26.07 a X	25.53 a X	29.47 a X	28.20 a X
Plant Height on 75 DAP (cm)	P1	31.60 a X	31.67 a X	30.15 a X	31.10 a X
	P2	36.47 a X	40.13 a X	36.00 a X	32.53 a X
	P3	30.80 a X	36.53 a X	36.47 a X	32.27 a X
Number of Leaves on 45 DAP (Strands)	P1	6.20 a X	5.53 a X	6.80 a X	5.80 a X
	P2	7.53 a X	5.80 a X	8.20 a X	5.80 a X
	P3	5.47 a X	6.80 a X	7.13 a X	5.33 a X
Number of Leaves on 60 DAP (Strands)	P1	8.67 a X	5.67 a X	9.00 a X	7.80 a X
	P2	8.93 a X	8.40 a X	7.28 a X	7.73 a X
	P3	6.00 a X	8.53 a X	9.73 a X	7.80 a X
Number of Leaves on 75 DAP (Strands)	P1	9.67 a X	9.87 a X	10.53 a X	8.50 a X
	P2	11.87 a X	9.87 a X	9.13 a X	8.87 a X
	P3	8.10 a X	10.80 a X	13.80 a X	9.07 a X

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%.

The analysis results of further DMRT test of the number of leaves in all observations showed no significant difference. Although it was not significantly different on 45 DAP, the best number of leaves was the treatment of 10 tons/ha of organic fertilizer, with Biochar, without hormone (P2B2H1), which reached 8.20 leaves. On 60 DAP and 75 DAP, the best number of leaves was treatment of 20 tons / ha of organic fertilizer, with Biochar, without hormones (P3B2H1), which reached 9.73 and 13.80 leaves. Therefore, although it is not significantly different, giving 20 tons / ha of organic fertilizer and 12.5 tons / ha of Biochar can provide better growth of shallots, while giving hormones has not increased the growth of shallots.

The application of organic matter to the soil plays an important role in improving the soil structure; thus, air aeration and water movement are smooth, thereby increasing the absorption of water in soil and able to increase plant growth and production [17]. In addition, the application of organic fertilizers can provide several benefits, such as better soil structure, increased nutrients available to plants, and increased soil microbial population and activity [18].

3.2. Components of production and productivity

3.2.1. Components of production. The results of further DMRT test analysis with a 5% confidence level toward yield components including dry weight of bulb / clump, number of bulbs/10 clumps, number of plants/ clumps, number of bulbs splitting, and bulb diameter are presented in Table 2 as follows.

Based on the results of further DMRT test analysis Table 2 with a confidence level of 5%, the interaction of the three treatments on the dry weight of bulbs/clumps, number of bulbs/10 clumps, number of bulbs splitting and bulbs' diameter gave significantly different results. The best dry weight / clump and bulbs' diameter were achieved by the treatment of 5 tons / ha of organic fertilizer, Biochar, and Hormone (P1B2H2), were 6.51 grams and 2.34 mm, respectively. The best number of bulbs / 10 clumps was achieved by the use of organic fertilizer 20 tons/ ha, biochar and without hormones (P3B2H1), was 12.67 tubers. The best number of plants / clumps and number of bulbs splitting was

achieved by the use of organic fertilizer 5 tons/ha, with Biochar, and without Hormones (P1B2H1), was 1.73 plants and 1.95 bulbs splitting, respectively.

Table 2. Dry weight of bulb/clump, number of bulbs/10 clumps, number of plants/clumps, number of bulbs splitting, and bulb diameter of true shallot seed (TSS)

Parameters	Fertilizer	Without Biochar (B1)		12.5 tons/ha Biochar (B2)	
		H1	H2	H1	H2
Dry weight of bulb / clump (gram)	P1	3.70 a XY	4.95 a XY	5,55 a XY	6,51 a X
	P2	3.52 ab X	3.32 ab X	2.87 ab X	3.32 b X
	P3	1.60 abc XY	2.53 abc X	3.98 abc XY	3.93 ab XY
Number of bulbs / 10 clumps (bulbs)	P1	3.93 ab XY	9.67 a X	12.33 a X	7.67 ab XY
	P2	11.67 a X	10.33 a X	12.33 a X	8.33 ab XY
	P3	3.00 b Y	7.33 ab XY	12.67 a X	9.33 a X
Number of plants / clumps (plants)	P1	1.47 a X	1.60 a X	1.73 a X	1.40 a X
	P2	1.60 a X	1.53 a X	1.40 a X	1.33 a X
	P3	1.18 a X	1.67 a X	1.67 a X	1.37 a X
Number of bulbs splitting (bulbs)	P1	1.33 ab XY	1.80 a X	1.95 a X	1.53 a X
	P2	1.93 a X	1.80 a X	1.64 a X	1.00 ab XY
	P3	0.00 b Y	1.47 a X	1.53 a X	1.47 a X
Bulb diameter (mm)	P1	1.60 ab Y	1.76 a XY	2.29 a XY	2.34 a X
	P2	1.84 a X	1.62 a X	1.62 ab X	1.69 ab X
	P3	1.20 bc XY	1.42 ab Y	1.80 ab X	1.56 bc XY

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%.

Provision of biochar 12.5 tons/ha can provide the highest yield because biochar provides many benefits. Biochar can stimulate growth, increase the availability of soil nutrients and increase crop yields as well as provide carbon needed by beneficial microbes for plants [19]. Biochar is a stable form of carbon and it can remain in soil for long periods. In addition, the application of biochar can provide a positive effect until the third growing season [20].

Research result showed that the treatment of gibberellin GA3 at a dose of 100 ppm on Lokananta variety of True Shallot Seed (TSS) gave significantly higher results than other treatments, on the vigor index and germination parameters, while the GA3 dose treatment at 50 ppm on Tuk Tuk variety of True Shallot Seed (TSS) gave significantly higher yields than other treatments, in case of the number of shallot leaves and tillers [21].

Hormone treatment in this study has not shown consistent results in every observed parameter. This is presumably because the application of this hormone is only done 3 times, namely on 20, 30 and 40 DAP, even though TSS at that age was still in the nursery phase because the total of harvesting period in shallot cultivation using seeds with a table system reaches 90-95 DAP (35 DAP is the nursery phase and 60 days later is the growth and generative phase of shallots) [22]. The hormone used is thought to have an effect, if it is increased the frequency of application at tighter intervals, and given until it reaches its generative phase, especially in bulb formation (until 80-85 DAP or up to approximately 10 days before harvest). The bulb formation phase usually occurs on 36-50 DAP (up to 10 days before harvest) while the bulb ripening phase is on 51-60 DAP (10 days before harvest) [23].

3.2.2. Productivity. Yield parameters in the form of fresh and dry productivity are presented in Table 3 as follows. Based on the result of Table 3, the highest productivity of wet and dry shallots per hectare was in the P1B2H2 treatment, namely the application of organic fertilizer as much as 5 tons / ha, with the addition of 12.5 tons / ha of biochar and hormones, reaching 4.6 tons / ha and 3.7 tons / ha. The productivity of the results of this study has not shown the actual yield potential because the TSS

cultivation system used was a direct seed planting system and when the research was on going, there was still raining. Therefore, the survival chances of TSS were low and plant performance was not optimal.

Table 3. Fresh and dry productivity of true shallot seed (TSS)

No.	Treatments	Fresh Productivity/kg/ha	Dry Productivity/kg/ha
1	P1BIH1	2622.4	2097.9
2	P1B1H2	3508.3	2806.65
3	P1B2H1	3933.6	3146.85
4	P1B2H2	4614.0	3691.17
5	P2B1H1	2494.8	1995.84
6	P2B1H2	2353.1	1882.44
7	P2B2H1	2034.1	1627.29
8	P2B2H2	2353.1	1882.44
9	P3B1H1	1134.0	907.2
10	P3B1H2	1793.1	1434.51
11	P3B2H1	2820.8	2256.66
12	P3B2H2	2785.4	2228.31

The results of the soil analysis before and after the study are presented in Table 4. Based on the results of soil analysis, before and after the study, showed that in the P1B2H2 treatment there was a highest increase of C-Organic from 0.77 (very low) to 1.36 (low), while P2B2H2 treatment had the highest CEC. Research result Nurida and Rachman [24], giving a dose of 5-7.5 t ha^{-1} compared with without soil repairer, it was able to increase the percentage of available water pores (PAT) to 9.18-10.11% vol from the original 6.69% vol (without soil repairer). Available P content increased to 29.12-30.71 ppm from 24.52 ppm (without soil repairer), total K increased to 5.13-6.43 ppm from 3.08 ppm (without soil repairer), soil CEC increases to 5.91-6.00 cmol (+) kg^{-1} from 4.71 cmol (+) kg^{-1}, and the respiration of microorganisms increased to 9.88-10.78 mg CO_2 kg^{-1} soil day-1 from the original 8.71 mg CO_2 kg^{-1} soil day-1 (without soil repairer).

Table 4. Soil analysis results before and after research

Treatment	Parameters					
	pH H2O - Electrometry	Criteria	C-Organic (%) Spectrophotometry	Criteria	KTK cmol (+) kg^{-1} Titrimetric	Criteria
Early land	7.6	Slightly alkaline	0.77	Very low		
P1B1H1	6.42	Slightly acid	0.92	Very low	21.00	Medium
P1B1H2	6.42	Slightly acid	0.83	Very low	17.71	Medium
P1B2H1	6.34	Slightly acid	0.99	Very low	21.76	Medium
P1B2H2	6.43	Slightly acid	1.36	Low	24.13	Medium
P2B1H1	6.52	Slightly acid	1.12	Low	21.66	Medium
P2B1H2	6.52	Slightly acid	0.96	Very low	22.25	Medium
P2B2H1	6.75	Neutral	0.92	Very low	27.08	High
P2B2H2	6.76	Neutral	0.93	Very low	27.38	High
P3B1H1	6.67	Neutral	1.06	Low	26.40	High
P3B1H2	6.69	Neutral	0.91	Very low	19.73	Medium
P3B2H1	6.73	Neutral	0.94	Very low	23.16	Medium
P3B2H2	6.77	Neutral	1.33	Low	22.83	Medium

4. Conclusion

The results showed that the application of 12.5 tons of biochar / ha was able to have a positive effect on the growth and production components of True Shallot Seed (number of plants / clumps, number of

bulbs / clumps, number of bulbs splitting, bulbs diameter and dry weight of bulb / clump). The use of organic fertilizer 5 tons / ha, with biochar and without hormones produced the best number of plants per clump and the best number of bulbs splitting, which were 1.73 plants and 1.95 bulbs splitting, respectively.

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